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FINAL REPORT

DEVELOPMENT OF PROTOCOLS FOR EVALUATING NOODLE AND STEAM BREAD QUALITY OF CANADIAN PRAIRIE SPRING (CPS) WHITE WHEAT

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Development of Protocols for Evaluating Noodle and Steamed Bread Quality of Canadian Prairie Spring (CPS) Wheat.

ADF Project 97000336

Final Report

Submitted to
Agriculture Development Fund
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SUMMARY

This project has allowed the development of protocols necessary to conduct selection for noodle quality traits at earlier stages in the Canada Prairie Spring White wheat breeding program that I have responsibility for. Four protocols have been developed to this end:

1. Small scale noodle
2. Small scale steamed bread
3. Polyphenol oxidases activity measurement on intact grain
4. Prediction of noodle whiteness using a raw white salted whole meal noodle.

This study used two sets of breeding lines during this project:

1. A set of 20 lines was used to develop the protocols. These lines were grown for two years at the Kernen Crop Research Farm and one year at the Saskatchewan Wheat Pool research farm at Watrous. These lines were derived from several crosses but had AC Karma as a common parent.

2. A second set of 30 lines was selected from a group of 500 lines. These lines were derived from 13 different crosses representing a somewhat broader genetic background than group 1. These lines were increased in New Zealand in the winter of 2000 to provide seed for tests which were completed by June 30, 2000. This second set of lines provided a means to validate conclusions obtained from the work on the 20 AC Karma related lines.

Two types of noodles were evaluated for color bush in raw and cooked states over time in this study, representing a broad spectrum of noodle types that are commercially produced and conditions that noodles often experience:

1. white salted noodle
2. alkaline noodle.

While developing these methods, color relationships between noodles made from flour and from whole meal were investigated. Being able to conduct quality tests on meal is vital to creating tests that can be used at earlier generations of a breeding program. The need for flour typically restricts testing to more advanced generations when the number of lines are fewer.

Noodle whiteness of both white salted noodles and alkaline noodles was found to be reliably predicted using colorimeter L-values measured on uncooked wholemeal white salted noodles. Whole meal was found to be generally not informative for colorimeter measurements. Noodle yellowness could not be predicted for either of the flour-made noodle types evaluated in this study. A PPO evaluation protocol was obtained from Dr. Craig Morris, USDA, Pullman, WA. Through use in this project, this PPO protocol was found to be a reliable test to detect low enzyme activity and thus slower declines in noodle whiteness.

Materials and Methods

Table 1. Thirty lines selected to represent the ranges of seven grain and meal parameters

NZ no.	CROSS	PEDIGREE
6001	UA10-1	U96025/SWP7708
6005	UA10-5	U96025/SWP7708
6013	UA10-13	U96025/SWP7708
6014	UA10-14	U96025/SWP7708
6024	UA10-23	U96025/SWP7708
6026	UA11-2	9124ED05D/WSP6668
6055	UA12-7	9124ED05D/SWP7708
6056	UA12-8	9124ED05D/SWP7708
6058	UA12-10	9124ED05D/SWP7708
6090	UA15-12	U95004/9124ED05D
6126	UA16-22	9124ED05D/9125DD03D
6152	UA17-11	9124ED05D/9126BH04D
6160	AC VISTA-4	HY344/7815-QX78B2//HY358*3/Bt10
6180	AC KARMA-5	(HY320*5/WB553//HY348)/(HY348/7915-QX76B2
6196	UA19-18	U96025/Cunningham
6206	UA19-27	U96025/Cunningham
6237	UA20-24	9125DD03D/QT5360
6238	UA20-25	9125DD03D/QT5360
6253	UA20-39	9125DD03D/QT5360
6257	UA20-43	9125DD03D/QT5360
6258	UA20-44	9125DD03D/QT5360
6277	UA21-11	9125DD03D/Cunningham
6316	UA21-48	9125DD03D/Cunningham
6331	UA22-10	9126BH04D/QT5360
6383	UA23-10	Cunningham/9126BH04D
6409	UA26-15	U95004/Cunningham
6418	UA26-24	U95004/Cunningham
6430	UA26-35	U95004/Cunningham
6476	UA29-5	U96025/9126BH04D
6482	UA29-10	U96025/9126BH04D

Test weight, kernel weight, protein concentration, and polyphenol oxidase activity was measured on the approximately 500 CPSW lines that were grown in New Zealand in winter 2000. On a subset of 100 lines selected to represent the ranges of the parameters measured, meal color (L, a, b values), sodium dodocyl sedimentation (a measurement of gluten strength), and falling number (a measure of alpha amylase activity induced by sprouting) were also measured. From this subset of 100, a smaller subset of 30 lines was further selected on which all noodle and

steamed bread tests were conducted (Table 1). These 30 lines represented the ranges of all of the measured parameters (Table 2). These lines are selections derived from 13 different crosses and represent a broader genetic diversity than the 20 AC Karma related lines that were used throughout most of the study. The methods used to select the 30 lines used in this part of the study are standard tests, so they are not presented in this report. The noodle and steamed bread procedures have been reported previously; however, they are reported here for completeness.

Table 2. Mean, range and standard deviation of the 30 New Zealand grown lines selected to validate previous studies

	TWT	KWT	PRO	PPO	SDS	FN
mean	81.89	49.91	14.13	0.47	59.13	393.13
largest	83.60	64.00	16.00	0.74	77.00	509.00
smallest	78.80	43.60	12.40	0.20	33.00	180.00
range	4.80	20.40	3.60	0.55	44.00	329.00
sd	1.18	4.87	1.02	0.15	8.82	73.02

Lab Scale 10 g Procedure for Preparation of White Salted or Alkaline Noodles

Reagents:

1. salt solution: 0.3 g NaCl / 4.00 ml. water
2. alkaline solution: 0.9 g Na_2CO_3 + 0.1 g K_2CO_3 / 100 ml water

Procedure:

1. Thoroughly mix all flour/ meal.
2. Weigh 10.0 g of sample into a plastic container.
3. Add 4.0 ml of salt solution (0.3 g NaCl/ 4.00 ml. water) and hand mix with a spatula (~ 10 – 20 seconds until no free water is visible).
4. Transfer to a coffee mill and mill for 10 seconds.
5. Transfer to a plastic container, cover and rest for 15 minutes at room temperature.
6. Transfer dough to metal containers, press to form dough, pass through #2 roll several times (fold the fold after each pass), and place in a closed plastic bag.
7. Rest the dough at room temperature in darkness for 30 minutes.
8. Sheet by successive passes through #2, #3, #4, #5, #6 roll gaps, one pass /roll while not changing directions.
9. Cut dough into 4 circles (5 cm in diameter) using the plastic cutter. Determine color of raw noodles.
10. Place 2 circles into boiling water for 5 minutes. Turn the noodles over several times.
11. Transfer the cooked noodle circles into a sieve and place in a running tap water bath for 1 min. Gently remove surplus water using paper towels.
12. Place the noodle circles into a plastic bag (2 circles/bag), measure color (L,a,b,YI) with Miniscan using DT65/10°.
13. Leave at room temperature. Determine color at 0, 2 and 24 hours.

Lab Scale Steamed Bread Preparation

The steamed bread procedure developed here was developed using information provided in the following papers:

1. Kruger et al 1992. Can. J. Plant Sci. 72: 369-375.
2. Huang et al 1993. J. Cereal Sci. 18:89-102.

Procedure:

1. Mixing
   - 200.0 g flour (14% moisture) in GRL-200 mixer
   - 89 ml of distilled water containing 3.0 g of compressed dry yeast - suspend yeast in water first
   - mix at 120 rpm for 1.5 minutes

2. Fermentation
   - transfer (as complete as possible) the dough into fermentation container
   - ferment at 32°C, 85% RH for 60 minutes

3. Sheeting and rounding
   - re-mix in GRL-200 at 120 rpm for 30 seconds
   - sheet the dough at 7/32 gap-setting 3 times then 5/32 gap-setting another 3 times (fold the dough end-to-end after each pass and resheet in a unidirectional manner
   - role the sheet to form a dough. Smooth the dough on the sheeting machine 20 times
   - cut the ends of the roll and divide the roll into 90.0 g pieces (3 pieces of 90.0g)
   - gently fold the ends together and shape the dough to form a rounded piece with a smooth upper face. Turn the dough around 12 times
   - place the rounded dough on a piece of parchment paper (or wax) into a tray. Cover with a moist cloth. ***The entire procedure should be completed within 4 min for 3 pieces.***

4. Proofing
   - place the tray back into the fermenter and proof at 32°C, 85% RH for 20 minutes

5. Steaming
   - add 1 L of distilled water into the steamer. Turn the heater on high 10 minutes before steaming. Place the buns in the steamer. Steam for 20 minutes.

6. Cooling
   - take buns from steamer, remove parchment paper and place buns on cooling racks. Cool for 15 minutes at room temperature. Cover buns with a moist cloth during cooling.

7. Determinations

Surface appearance was evaluated subjectively immediately after cooling for presence of wrinkles, dimples, blisters and gelatinized spots. Bun width (two measurements), height and volume (using a loaf volume meter with rapeseed displacement) was also measured immediately.

Color measurements (L, a, b, YI) were measured on the bun surface and crumb. A piece of bun was also eaten to provide a subjective measure of mouthfeel (sponginess). Texture profile analysis was conducted on 4x3x2 cm (LxWxH) centre pieces using 70% compression after being stored overnight in a plastic bag.

Estimating PPO Activity

This procedure was obtained from Dr. Craig Morris and tested with our materials. This method is discussed in the paper: Distribution of PPO Activity Among a Large Number of Hexaploid Wheat Genotypes Using an Improved L-DOPA Assay. C.F. Morris, J.V. Anderson, A.D. Bettge, R.J.Rogahn & M.E. Correll. USDA-ARS Western Wheat Quality Lab, Pullman,WA 99164

Reagents:
50 mM MOPS solution:
50 mM = 209.3 x 0.05 (g)/ 1 L
= 10.465 g/L or 1.05 g/100 ml
5mM L-DOPA solution:
5mM= 197.2 x 0.005
= 0.986 g/L
= 0.0986 g/100 ml of 50 mM MOPS
Procedure:
1. 1.5 ml of 50 mM MOPS, 5 mM L-DOPA, pH 6.5 is added to 5 kernels of wheat in a 2 ml microfuge tube (rounded bottom) at 30 second intervals.
2. Tubes are rotated or mixed for 30 minutes to allow the reaction to take place. The air bubbles in the tubes must be allowed to mix with the kernels and solution.
3. At the end of incubation time, spectrophotometer absorbance at 475 nm is read using a 1 ml sub-sample. Readings are done at 30 second intervals as this is a time dependent chemical reaction.

Results and Discussion

A quote I heard recently about the noodle business stuck a clear note with me as regards to application of plant breeding methods for improved noodle type wheats: "color attracts the customer while texture keeps the customer". Thus, the emphasis and study of color selection for CPSW breeding is justified.

For earlier generation plant breeding tests, whole meal is the preferred material for testing because of the time required to produce flour. Thus the aim of much of this project has been geared to evaluating the utility of tests on whole meal for color prediction of noodles and steamed bread.

Table 3. Correlations between L-values from whole meal, whole meal noodles and noodles made from flour measured immediately after processing

			Correlations with meal L-values [A]		Correlations with raw whole meal salted noodle L-values	
Material	Noodle type	Condition	NZ lines	AC Karma lines	NZ lines	AC Karma lines
meal	-	-	1.00	1.00	-0.04	0.00
	alkaline	raw	0.06	0.08	0.57	0.75
		cooked	0.11	0.57	0.72	0.05
	salted	raw	-0.04	0.00	1.00	1.00
		cooked	0.11	0.66	0.87	0.00
flour	alkaline	raw	-0.14	-0.20	0.78	0.62
		cooked	0.08	-0.11	0.66	0.46
	salted	raw	-0.20	-0.01	0.79	0.45
		cooked	-0.15	0.33	0.73	0.49

[A] Correlations greater than 0.36 or less than -0.36 are significant at α=0.05.

Noodle color is defined by its brightness (L-values) and its yellowness (b-values) with a-values approaching zero (not too red and not too green). The color of the raw or cooked flour noodles is what a customer will look at when purchasing a product and is the target which must be predicted in plant breeding screening tests.

Noodle whiteness

The colorimeter (L, a, b, YI) values were measured and correlations were calculated amongst the various measurements of meal, and two kinds of noodles (white salted, alkaline),

raw or cooked and at 0, 2 and 24 hours after noodle preparation. Whole meal L-values did not predict noodle color in most comparisons using the New Zealand grown lines and was thought to be due to the narrow range of values observed. However, the color of uncooked, wholemeal

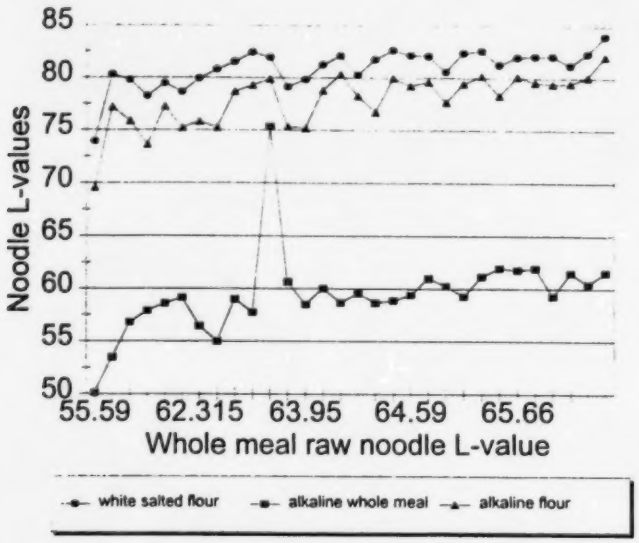

Figure 1. Association of L-values from three types of raw noodles with whole meal raw white salted noodle L-values of New Zealand grown lines sorted from lowest to highest. The one outlier data point in the alkaline whole meal dataset is probably an error in data entry.

salted noodles was well correlated with the other noodle types whether uncooked or cooked (Table 3). In the previous work reported, meal L-values were sometimes correlated with noodle L-values but not always. It appears that a noodle made from whole meal can be used to predict whiteness in processed noodle products, but the color of unprocessed whole meal is not a useful predictor. Figures 1 and 2 demonstrate the relationships of the noodle L-values and how these can be used to select breeding lines that can produce a whiter noodle.

Noodle yellowness

A similar analysis was done for yellowness by evaluating colorimeter b-values. Although significant correlations were observed between whole meal b-values and b-values of cooked alkaline or salted noodles made from flour, these correlations were not repeated when the New Zealand grown material was tested (Table 4). Significant correlations were not observed between meal b-values and b-values from uncooked noodles made from flour. When the b-values of a raw white salted noodled made from whole meal were used as predictors (as was done for L-values above), only one significant correlation was observed with the flour made noodles from either the New Zealand grown material or combined data of previously reported work (Table 4). Other possible correlations were also investigated, but these too were not predictive of final noodle

color. Variability in bran yellowness as well as changes in yellowness due to noodle preparation and cooking likely served to aggravate predications of yellowness in noodles made from flour. It would appear that yellowness of flour or noodles prepared from flour cannot predicted from color measurements of meal.

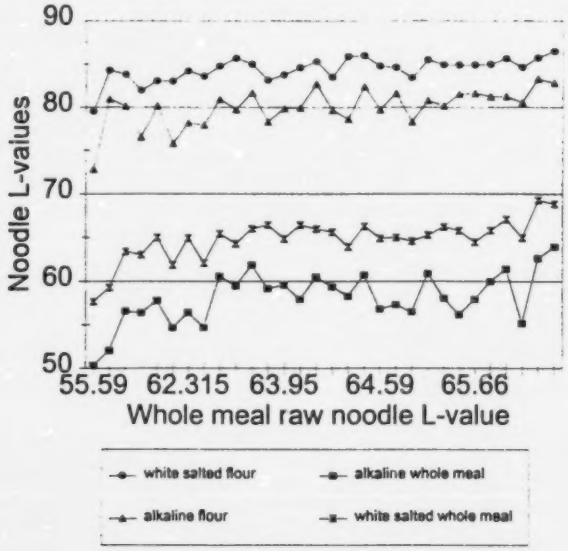

Figure 2. Association of L-values from four types of cooked noodles with whole meal raw noodle L-values of New Zealand grown lines sorted from lowest to highest.

Polyphenol Oxidase Activity

Polyphenol oxidases (PPO) are a group of enzymes that cause browning reactions after noodles are sheeted. A noodle that is white when freshly made may change to a undesirable brown or green color in several hours. The effect of PPO is to reduce noodle whiteness which has been well reported in the literature (Baik et al. 1995) and was observed in this study also (Table 5). The New Zealand grown material demonstrated the expected negative correlations between PPO activity and noodle whiteness with both raw and cooked noodles that were made from flour (Figures 3 and 4). The data reported previously also demonstrated this trend but less definitively. This has been attributed to an improved method we adopted from Dr. Craig Morris which uses L-DOPA in a buffered solution as a PPO enzyme substrate rather than catechol in an unbuffered solution. Experience developed with this test is now being applied to the CPSW breeding material providing more reliable selection for low PPO activity in breeding lines. The effect of cooking can be observed in Figures 3 and 4 as heat tends to degrade the PPO enzymes. Thus the cooked noodles are generally whiter than the raw noodles after they have been resting at room temperature for 24 hours. This effect is less obvious with the alkaline noodles. The relative change in whiteness of white salted noodles was significantly correlated with PPO activity and can be observed in Figure 3.

Table 4. Correlations between b-values from whole meal, whole meal noodles and noodles made from flour measured immediately after processing

			Meal b-values ^		Raw whole meal salted noodle b-values	
Material	Noodle	Condition	NZ lines	AC Karma lines	NZ lines	AC Karma lines
meal	-	-	1.00	1.00	-0.17	0.41
	alkaline	raw	0.17	0.51	0.54	0.64
		cooked	0.35	0.18	0.50	0.35
	salted	raw	-0.17	0.41	1.00	1.00
		cooked	0.35	0.28	0.44	0.47
flour	alkaline	raw	-0.31	0.24	0.24	0.21
		cooked	0.22	0.56	0.04	-0.01
	salted	raw	0.18	0.25	0.16	0.48
		cooked	0.06	0.59	0.14	0.00

^ Correlations greater than 0.36 or less than -0.36 are significant at α=0.05.

Table 5. Correlations between polyphenol oxidase levels measured in whole grain and L-values measured at 24 h after processing from noodles made with whole meal or flour.

Material	Noodle type	Condition	NZ lines	AC Karma lines
meal	alkaline	raw	-0.23	0.02
		cooked	-0.29	-0.43
	salted	raw	0.02	-0.06
		cooked	-0.42	-0.32
flour	alkaline	raw	-0.51	-0.35
		cooked	-0.61	-0.32
	salted	raw	-0.56	-0.53
		cooked	-0.50	-0.27

^ Correlations greater than 0.36 or less than -0.36 are significant at α=0.05.

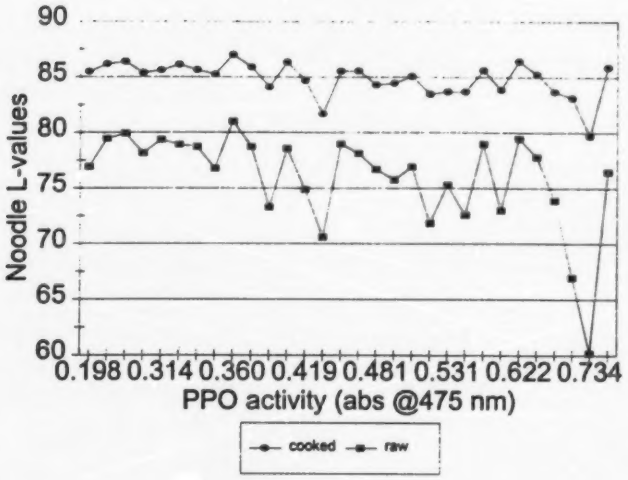

Figure 3. Noodle whiteness of white salted noodles made with flour in relation to intact grain polyphenol oxidase activity (PPO). Measurements were taken 24 hours after noodles were made.

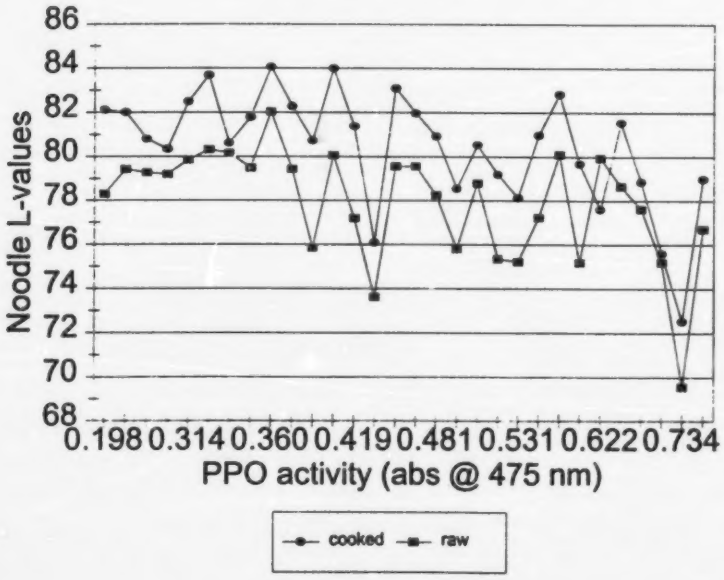

Figure 4. Noodle whiteness of alkaline noodles made with flour in relation to intact grain polyphenol oxidase activity (PPO). Measurements were taken 24 hours after noodles were made.

Protein concentration and color

Although protein concentration has been shown in the literature to cause discoloration of dough for oriental noodles (Baik et al. 1995), we were not able to demonstrate this with either of the sets of samples used in this study.

Steamed Bread Color and Texture

Steamed bread color was evaluated on both the skin of the bun and the internal bun crumb. Skin L, a, b, and YI values were significantly correlated with their respective crumb measurements in both the New Zealand grown material and the AC Karma related lines except in one instance for an a-value. From previously reported data, flour was a good predictor of skin and crumb whiteness ($r=0.87$, $r=0.61$, $P<0.01$, respectively). However, meal color was not a useful predictor in most cases for any steamed bun color measurement in either the New Zealand grown materials or with the previously reported data set.

Steamed Bread Texture Analysis

The texture analysis used a two stroke compression of a section of a steamed bun for the analysis. The width of the steamed bun showed repeatedly strong negative correlations with TPA hardness, gumminess and chewiness measurements (Table 6). Bun volume and height were generally not predictive of TPA parameters. SDS sedimentation, a measurement of gluten strength, did not appear to influence bun dimensions or texture parameters. A high volume bun with some broadness at the base appears to represent a bun with appropriate textural characteristics.

Table 6. Correlations of steamed bread size with textural characteristics

	New Zealand grown material			Previous sample set		
	Width	Height	Volume	Width	Height	Volume
Hardness	-0.82[A]		-0.48	-0.64		-0.29
Adhesive Force	0.50	-0.04	0.36	0.27	-0.41	0.00
Springiness			0.25			0.41
Gumminess	-0.76		-0.41	-0.64		-0.27
Chewiness	-0.40			-0.54		

[A] Correlations greater than 0.36 or less than -0.36 are significant at $\alpha=0.05$.

INDICATIONS FOR FUTURE DEVELOPMENT

1. We will be investigating noodle texture measurements as a possible method for evaluating noodle eating quality. This is still a very nebulous area as there are large regional differences in desired eating quality as well as differences among noodle products. This work will be done in collaboration with researchers at the Grain Research Laboratory in Winnipeg who have a lot of experience in this area.

2. Development of NIR methods to predict quality parameters will be investigated using a well characterized genetic population. This is underway in another project.

PERSONNEL

1. Helen Ly completed her work on this project in good time with minimal supervision. Efforts were made to ensure that the techniques she was using were learned by other staff in the CDC wheat quality laboratory.

EQUIPMENT (FOR $500 OR MORE)

No equipment was purchased during the reported period.

PROJECT DEVELOPED MATERIALS

1. An early generation test to predict the whiteness of noodles using a raw salted whole meal noodle.

2. An effective early generation test to predict low polyphenol oxidase activity using intact grain.

3. We have developed an effective lab scale noodle making technique.

4. We have developed an effective lab scale steamed bun making technique.

PUBLICATIONS

Zheng, G.H., and S.L. Fox. Evaluating Noodle Quality of CPS Wheat. Soils and Crops Symposium Feb. 25-26, 1999. pp 349-353. Extension Division, University of Saskatchewan, Saskatoon.

EXPENSE STATEMENT

A detailed expense statement will be mailed by University Research Accountants.

An addendum to the Final Report for Project 97000336

1. Impact of developed tests in assessing wheat breeding lines for noodle quality.

The primary goal of this project from my perspective was to develop noodle quality tests that could be used at earlier generations in a breeding program. Upon my taking over of the CPS wheat breeding program, these tests were not in place, and the available tests were dependent on using flour. Having to use flour restricts testing to later generations of a breeding program.

a. Impact to researchers: After a few years of implementation of these tests, a paper will be published on their use. I wish to conduct comparative tests using material from replicated yield tests before this can be done. I am unaware of methods for noodles that utilize whole meal, so a publication in this area may be of some benefit to other plant breeders.

b. Impact on producers: Better selection procedures should produce cultivars that have better market acceptance and thus command better prices. The quality definition of the CPS white class of wheat is still undergoing changes. Thus producers have discovered that cultivars in this class fall out of favour as the definition is clarified.

c. Impact on markets: The current market for flour used to produce noodles is quite competitive as substitutions of one flour source for another can be made more easily than is the case with flour used to produce raised bread products. No single flour is used to produce a noodle except in rare instances. Thus the goal of my breeding program is to produce a cultivar that can form the reliable basis of many flour grists used to produce different kinds of noodles. The cultivar requires the characteristics that do not discount its use in these grists. These characteristics include the following:

1. Flour whiteness: yellow flours are more common than whiter ones. White flour is less likely to be discounted due to color and allows final product yellowness to be controlled.
2. Polyphenol enzyme activity: low enzyme activity is preferred as raw noodle products will experience browning reactions.
3. End-use textural characteristics (not explored in this project)
4. Kernel hardness (not explored in this project)

Good flour colour is critical for the wide market acceptance of a wheat cultivar used to produce noodles.

2. The Nisshin Flour Milling Company provided us with standard flours of alkali Chinese noodles and white salted Japanese noodles that were used in the 10 g noodle procedure and various noodle colour measurements were taken. These data are reported in the August-December 1998 progress report, Figures 3-9. As a rule, the standard flours were whiter and less yellow than the CPS lines that were used in this project. However, the standard flours had similar rates of colour change to that of the CPS lines.

3. Statistical analysis

With the CPS lines that were tested in Kernen in 1997 and Watrous and Kernen in 1998, analyses of variance (ANOVA) were carried out using each environment as a replication. These ANOVA were used to ascertain whether significant variation existed among the lines used. Note

that of the 20 lines that were selected for use, lines 11 and 14 were discontinued because of poor agronomic performance after the first year of testing. AC Vista was tested in both 1998 environments. For convenience of analysing balanced data, only 17 lines were included in these ANOVA.

The New Zealand grown material was evaluated once using a sample of 30 lines selected for 400. The 30 lines represented a range of protein concentration, SDS sedimentation volume and meal colour that exceeded that of the 20 AC Karma derived lines. As only single evaluations were available, a correlation matrix was calculated to analyse results.

ANOVA were calculated using Agrobase 98 software and correlation matrices were calculated using Corel Quattro Pro V9 or Minitab Statistical Software.

4. Identification of technical indices used to evaluate CPS white wheat breeding lines.

The primary goal of this project was not to identify new indices with which to evaluate CPS wheats but rather create small scale noodle and steamed bun protocols which various indices could be applied. For noodle products, colour and texture are two primary characteristics that are measured. This project was restricted to studying only colour and factors that cause colour change (polyphenol oxidase enzymes). We were successful in developing a small scale noodle test using whole wheat meal that correlated well with flour made noodles for both alkaline and white salted noodles (Final report, Table 3). This test was validated on breeding lines (referred to as NZ lines in the final report) and will be used as part of routine screening of 100-200 lines per year. We have already used this 10 g noodle protocol in another ADF project (98000331-70BW).

The small scale steamed bun protocol was developed so that 100 g or less of flour is required to make three buns. This test could not be converted to a meal type test and meal colour and a whole meal noodles were found not to be predictive of the skin or crumb colour of the resulting steamed bun. This test will be used as a later generation test.

We adopted a PPO test originally published by Craig Morris, USDA Pulman WA. This test performed well in our hands and correlated well with the colour of raw noodles stored for 24 hours (August-December 1998 Progress Report, Figure 10), meeting the expectation that lines with higher PPO activity would produce raw noodles that become less white after storage.

5. Publications and Conferences

I intend to publish a methods paper about the 10 g noodle protocol following its application on a third set of materials. This work is already underway. I will be attending the American Association of Cereal Chemists meeting in 2001 and will present this method in a poster as part of a larger study.